

## REINTRODUCING FIRE IN EASTSIDE PONDEROSA PINE FORESTS: A LONG-TERM TEST OF FUEL TREATMENTS

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### ABSTRACT

Coniferous forests east of the crest of the Cascade Range in Oregon and Washington have changed substantially in the last 100 years. Much of this change, manifested in accumulated litter and dead and dying trees, increased stand densities, altered species compositions, and disruption of historic insect population levels, can be attributed to decades of fire exclusion and past management activities. The current structure and composition of many eastside forest stands, especially late-successional and old-growth ponderosa pine stands, places them at greater risk of replacement from wild-fire. Throughout the West, forest managers are interested in prescribing a series of repeated underburns to return fire to pre-exclusion frequencies and intensities, and thereby maintain and protect old-growth structural characteristics. Yet there is little quantitative information available on the effect of repeated prescribed fires in these high-risk systems. We describe a long-term study designed to develop a better understanding of key ecosystem attributes and functions that may be affected by reintroducing fire in fire-dependent ecosystems. Our work is focused on *Pinus ponderosa*/*Purshia tridentata* stands within the 581-hectare Metolius Research Natural Area on the Deschutes National Forest in central Oregon, an area currently exhibiting symptoms of fire exclusion including reduced rates of tree growth, accumulated litter and ladder fuels, senescent shrubs, and dense regeneration of *Pinus ponderosa*. Burns at 5-, 10- and 20-year intervals were chosen to resemble natural fire-return intervals and were initiated beginning in 1992. Initial results compare horizontal and vertical structure components of trees in late-successional/old-growth forests and how these components are modified by periodic fire, how underburns affect understory

plant species diversity, and the relation between over-story canopy cover and understory species composition and cover. We believe this study will increase our understanding of how natural disturbances and human-caused manipulations can affect forest health over a long time, and lead to new options for protecting old-growth structural characteristics.

Key words: fire restoration, fuel reduction, long-term study, Metolius Research Natural Area

### INTRODUCTION

Low elevation coniferous forests east of the crest of the Cascade Range in Oregon have changed substantially in the last 100 years. At the landscape scale, early settlers and surveyors at the turn of the century passed through open forests with widely spaced trees, few if any down logs, and little litter and woody undergrowth (Languille, H. D. et al. 1903). The pattern of forests dominated by ponderosa pine (*Pinus ponderosa* Laws), as suggested by early settlers' journals, was a seemingly uniform park-land of widely spaced, medium to large old trees and continuous herbaceous undergrowth (Agee, J. K. 1994); this description best fits the "Old Forest Single Strata" stand structure class (O'Hara, K. L. et al. 1996). Land survey witness trees established during the late 1800s in what is now the Ochoco National Forest were predominantly ponderosa pine with diameters that exceeded 53 cm at 1.37 m in height (Karr, J. R. and Chu, E. W. 1994). The pattern of large trees in park-like openings before the 1900s was substantially the result of repeated fires that lead to vertical stratification of fuels (Agee, J. K. 1990). Dendrochronology evidence from 600-year-old pine at Pringle Butte in central Oregon indicated at least 139 fires occurred between 1362 and 1900, with a mean

fire return interval of 4 years and an average of 11 years for individual plots (Bork, J. L. 1984, Morrow, R. J. 1986).

Since the turn of the century, the structure and composition of forests east of the crest of the Cascade Range has changed. Most of the change can be attributed to two historical management activities: effective fire exclusion, beginning with the creation of the Forest Reserves in 1905, and widespread selective timber harvesting that started with the first European settlers and greatly accelerated after World War II (Bergoffen, W. W. 1976). With effective fire exclusion, understory tree density in low-elevation forests has increased, stand composition has been altered to include more lodgepole pine (*Pinus contorta* Douglas ex Loudon) and grand fir (*Abies grandis* (Dougl.) Forbes) on some sites, and stands are at greater risk of replacement (Mutch, R. W. et al. 1993, Agee, J. K. 1994). These stands now fit the "Old Forest Multi-Strata" stand structure class (O'Hara, K. L. et al. 1996). Current levels of ponderosa pine in "Old Forest Single Strata" represent only 3 to 5 percent of hypothesized historic levels (Karr, J. R. and Chu, E. W. 1994). Other changes in stand dynamics also are apparent; populations of mountain pine beetle (*Dendroctonus ponderosae* Hopkins), and pandora moth (*Coloradia pandora* Blake), have increased dramatically and are attacking trees with low vigor (Larsson, S. et al. 1983, Hessburg, P. F. et al. 1994).

There is widespread recognition of the need to restore health and resiliency to eastside forest ecosystems (Quigley, T. M. et al. 1996). Some managers are attempting to restore the frequency and intensity of disturbances and thus the resulting periods of stability through a series of light, periodic underburnings that reduce fuels and minimize stand-replacement fires (Mutch, R. W. and Cook, W. A. 1996). Although fire is well recognized as a disturbance process that affects stand structure and dynamics, nutrient availability, wildlife habitat, and insect and plant disease populations (Rogers, P. 1996), the short- and long-term effects of underburning in low elevation, late successional or old-growth ponderosa pine forests are not well understood. The degree to which prescribed underburning mimics historic fires in frequency and severity is not known, nor is there a clear understanding of the types of stand structures and their related values that can develop after prescribed fire.

We describe a long-term experimental study designed to develop a better understanding of key ecosystem attributes and functions that may be affected by reintro-

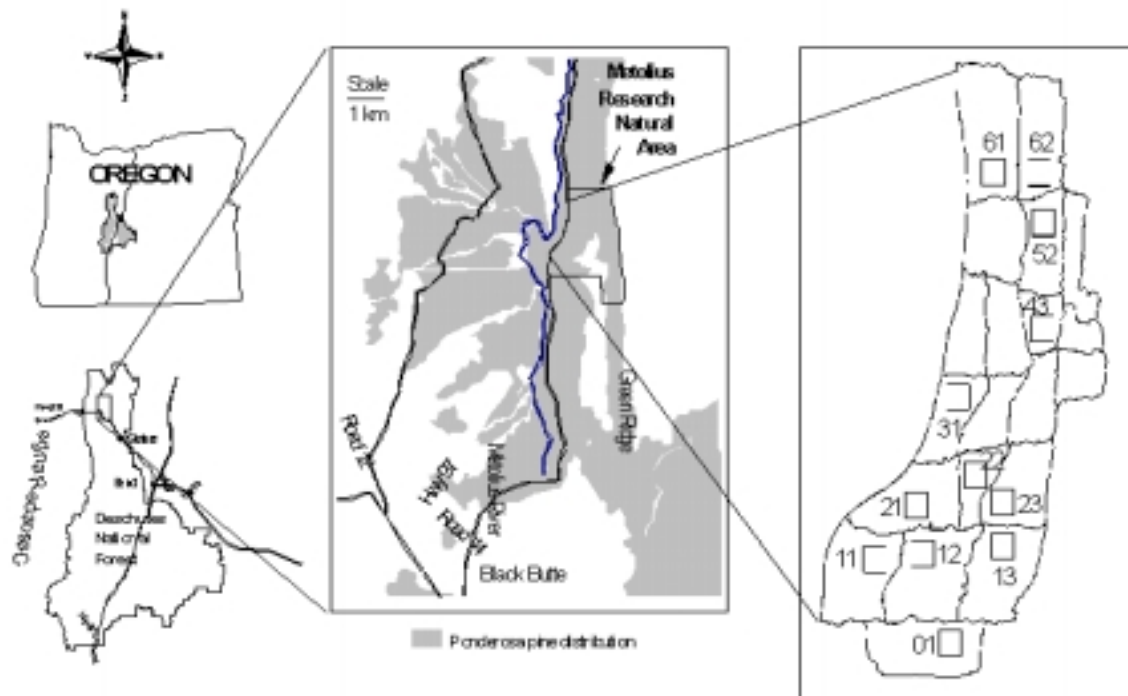
ducing fire in fire-dependent ecosystems. We are aware of only one other attempt to quantify the effect of burns repeated at different intervals over time; tree growth was evaluated over an 11-year period for fire intervals of 1, 2, 4, 6, 8 and 10 years (Peterson, D. L. et al. 1994). In our work, burns at 5-, 10- and 20-year intervals were chosen to resemble natural fire-return intervals and were initiated beginning in 1992. In this paper, we present our conceptual approach and methodology for this study, site characterization and initial conditions, initial results comparing horizontal and vertical structure components of trees and how these components are modified by periodic fire, and preliminary observations on how underburns affect understory plant species diversity.

A long-term experimental study, especially one with the planned duration and complexity of this study, is expensive and time-consuming. A logical question is, "Why not examine previously-treated areas, i.e. why not a retrospective study?" We believe strongly that opportunities to better our understanding of the role of fire include retrospective studies and anecdotal observations. These opportunities usually involve consideration of fire effects on widely varying sites, however, with little knowledge of stand or site conditions before the fire, often poor documentation of fire behavior during the burn, and little consideration of the role other disturbance factors may have contributed to changes in stand structure. In contrast, an experimental approach like ours provides for the selection of uniform sites before treatment, the spatial and temporal synchronization of treatments, the random assignment of treatments, and an assessment of various processes affected by the treatments, thus allowing much stronger inferences from the results.

## METHODS

### Study Area

This study was established within the 581-hectare Metolius Research Natural Area (RNA) in central Oregon, on the Sisters Ranger District, Deschutes National Forest (Figure 1). This area, protected from large-scale vegetation manipulations since 1931, exemplifies ponderosa pine and shrub-dominated communities on the east slopes of the Cascade Range (Hall, F. C. 1972). The study area (latitude 44°30' N, longitude 121°37'30" W) lies on a nearly flat bench (elevation 900 m) and conforms to the ponderosa pine/bitterbrush/western needlegrass plant association (Volland, L. A. 1985). Soils are well drained, devel-



**Figure 1. Location of the burn units and study plots within Metolius Research Natural Area, Deschutes National Forest, Oregon.**

oping in basalt and andesite residuum overlain with 2-5 cm of dacite pumice from ancient Mount Mazama and  $\leq 7$  cm of basaltic ash from cinder cones to the east. A modified continental climate prevails, with mean annual precipitation about 365 mm occurring mostly as snow. The RNA currently exhibits symptoms of fire exclusion including reduced rates of tree growth, accumulated litter and ladder fuels, senescent bitterbrush (*Purshia tridentata* Pursh (DC)), and dense regeneration of ponderosa pine, Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and grand fir.

In an attempt to reduce the risk of catastrophic fire, restore natural processes, and reinstate natural disturbance regimes, a fire management program that included reintroduction of fire on about 250 hectares of the RNA was initiated with a series of spring burns beginning in 1990. Pre-burn fuels were characterized by the District for each separate burn prescription. Although pre-burn sampling for stand structure, stem damage, and understory vegetation did not occur, these burns were generally of such light intensity that little bole consumption occurred, all stems standing before the burns are still recognizable, and the complete pre-burn structure can be re-created.

### Treatments and Experimental Design

We selected 12 burn units in a randomized block design with four treatments (three burn intervals and a control). Blocking is based on year of initial burn to compensate for potential confounding effect of annual variability in weather and the synchronous effect of short-term climatic patterns that might occur. In each unit, we established a 1-ha square plot on which fuel reduction, litter consumption and new litter deposition, overstory stand structure, spatial arrangement, tree mortality, understory species composition and productivity, light availability, and changes in soil carbon and productivity will be characterized. Controls, which received no burning, were randomly assigned one to each block. Each treatment occurred once in each block. All units, with the exception of those assigned the control treatment, were first burned in the spring of 1992, 1993, or 1994. All future burns are planned as fall burns. The first set of reburns occurred in the fall of 1997 and 1998. Scheduled treatments are listed in Table 1.

	Units	Size (ha)	Treatment	Timing of burns
<b>Block 1</b>	11	10.2	Control	None
	62	8.5	5-yr return	1992, 1997, 2002, 2007, 2012
	12	11.3	10-yr return	1992, 2002, 2012
	52	6.4	20-yr return	1992, 2012
<b>Block 2</b>	22	4.0	Control	None
	61	12.3	5-yr return	1993, 1998, 2003, 2008, 2013
	43	3.6	10-yr return	1993, 2003, 2013
	23	7.7	20-yr return	1993, 2013
<b>Block 3</b>	01	12.0	Control	None
	21	9.3	5-yr return	1994, 1999, 2004, 2009, 2014
	31	5.9	10-yr return	1994, 2004, 2014
	13	9.9	20-yr return	1994, 2014

**Table 1. Schedule of treatments by unit and block, Metolius Research Natural Area.**

### Data Collection

Stand structure was characterized in a single 100 X 100-m (1 ha) plot for each treatment unit. Each plot was systematically located based on a shared reference point at treatment unit corners and a measured distance without any preconceived bias of stand structure or past burn homogeneity. All trees  $\geq 15$  cm tall and larger were tagged and mapped using a survey laser to measure angle and distance to each tree from known reference points in 16 25 X 25-m cells. Species, diameter at breast height (dbh), height, crown vigor (subjectively classified as good, fair, or poor), and crown class (classified as dominant or emergent, codominant, intermediate, or below the lower continuous canopy) were recorded for each live tree. Dead trees were recorded by species, dbh, height, and height of bark char.

To characterize the complete tree population in each 1-ha plot, we tagged and mapped each tree, including well-established seedlings and snags. Mapped point locations for each tree provided the basis for addressing how repeated burns will, over time, affect the horizontal stand structure and provide a measure of when units begin to resemble pre-fire exclusion stand conditions. Two procedures for analyzing spatial patterns of the completely mapped tree data were used. The procedures, known as nearest-neighbor analysis and Ripley's  $K(d)$  function, consider the cumulative distributions of horizontal distances between points or tree locations, compared to a distance distribution for a point pattern generated by a random process (Moeur, M. 1993). The horizontal distance distribution of trees in different mortality class, size class, species, tree vigor, canopy condition and treatment were analyzed separately by plot. The objective was to discern the

effect of fire on spatial patterns, stand development processes, and competitive interactions.

The nearest-neighbor analysis considers trees as point locations in a closed plane and tests whether a given point pattern departs from randomness toward clustering or regularity. The procedure used only tree-to-nearest-tree distances, summarized across all trees in the population.  $F(d)$  is the cumulative distribution function describing the probability that a nearest neighbor is within distance  $d$  of a specified tree. If the empirical cumulative distribution of distances is greater than that of a random distribution, meaning that there are more observed nearest-neighbor distances in circles of radius  $d$  than expected under a Poisson assumption, then the observed pattern is said to be clustered. If the empirical distribution is less than a random distribution, the pattern is uniform. A 95% confidence envelope surrounding the expected or theoretical distribution was calculated based on 100 iterations.

Ripley's  $K(d)$  analysis considers the distances between all pairs of points in the plane. The function  $K(d)$  was linearized such that the expected value representing a random distribution is zero, so that positive values represent aggregation or clustering and negative values represent uniformity or regularity.

Understory vascular vegetation was measured on a series of three permanent 100-m transects established in each plot. Canopy cover of herbaceous species, shrub, and tree germinants ( $< 15$  cm in height), litter, bare ground, rock, and wood were ocularly estimated within a 20 X 50 cm microplot spaced every 10 m on each transect (Bonham, C. D. 1989). To determine current year's growth of herbaceous plants, aboveground bio-

mass was clipped at peak standing crop near the top of the litter surface from 10 50 X 50 cm microplots along each transect. The dominant species was determined in the 1995 field season and up to ten species and two life forms (other graminoids and other forbs) were clipped and bagged separately. To minimize competition from other species, successive harvests were clipped at different locations off the canopy cover transects. Biomass was dried for 48 hours at 60°C and weighed. Shrub cover was quantified using a line-intercept method (Bonham, C. D. 1989) along the same vegetation transects. Average shrub height along each transect was estimated to the nearest decimeter.

Bitterbrush, greenleaf manzanita (*Arctostaphylos patula* Greene), and snowbrush ceanothus (*Ceanothus velutinus* Dougl.) seedlings and sprouts were enumerated along the line intercept and their locations noted for remeasurement. Bitterbrush, greenleaf manzanita, and snowbrush ceanothus were aged in adjacent stands outside of the treatment plots to assist in interpretation of sprouting response to burning. A key question addressed in this research is the effect of fall burning on sprouting, and the relative productivity from sprouting or seeding.

Tree mortality and ingrowth within the plots will be assessed at 5-year intervals, beginning in year 2001. Trees killed by the prescribed fire will be permanently tagged and monitored to establish tree fall rates.

## RESULTS AND DISCUSSION

### Understory Responses

Burning decreased the cover of some mid- and late-seral and fire-sensitive herbaceous species, such as Idaho fescue (*Festuca idahoensis* Elmer), western fescue (*Festuca occidentalis* Hook.), and *Collomia grandiflora* Dougl. Early seral and fire-adapted species such as squirreltail (*Sitanion hystrix* (Nutt.) J. G. Smith) and bracken fern (*Pteridium aquilinum* (L.) Kuhn) increased to four or five times that of the controls.

An interesting observation was the presence of common comandra (*Comandra umbellata* Nutt.) that appeared after the burns. Comandra is the alternate host of the Comandra blister rust (*Cronartium comandrae* Pk.). This native disease of ponderosa pine begins infection in the crown and slowly progresses down the bole, killing the tops and producing excessive resin flows as the wood becomes case-hardened, resulting in dead tops that resist decay and may serve as long-standing snags. Many large, old trees in Metolius RNA

were killed by Comandra blister rust during the 1950s, with infection presumably occurring during a period of cooler, more moist climate that favored spore production (Filip, G. M. 1977).

Nearly all of the existing bitterbrush cover was consumed during the initial spring burns. The literature is contradictory on the ability of bitterbrush to sprout after fire. Throughout the pumice zone in central Oregon and northern California, sprouting occurs infrequently. Bitterbrush cover at Metolius increased after the burns as a result of recruitment of new plants from seed buried in rodent caches. Successful caches were made in the interspaces between shrubs where litter is sparse. Cover declined in the third and fourth years after burning owing to sprout and seedling mortality.

### Overstory Responses

Stem mapping and stand structure characterization for all 12 units was completed in 1998. Density ranged from 509 to 3403 stems·ha<sup>-1</sup> and averaged 1853 stems·ha<sup>-1</sup>. Basal area ranged from almost 25 to over 42 m<sup>2</sup>·ha<sup>-1</sup> and averaged 31 m<sup>2</sup>·ha<sup>-1</sup> (Table 2). Units that were burned averaged 57 large live stems with a mean diameter of 60.6 cm, 10 large dead stems with a mean diameter of 65.8 cm, 627 small live stems with a mean diameter of 11.3 cm and 1120 small dead stems with a mean diameter of 5.2 cm. Control, unburned units averaged 44 large live stems with a mean diameter of 70.4 cm, 9 large dead stems with a mean diameter of 67.4 cm, 1025 small live stems with a mean diameter of 9.6 cm, and 247 small dead stems with a mean diameter of 4.6 cm. Underburning greatly reduced the number of small live suppressed trees and seedlings, with no apparent effect on the density of overstory strata. The percentage of large live stems was 4.5 in burn units and 2.6 in control units, and the percentage of large dead stems was 1.1 in burn units and 0.5 in control units after the first series of burns. In contrast, small live stems represented 35.8% in burn units, and 52.5% in control units, small dead stems represented 57.4% in burn units and 11.8% in control units, and seedlings represented 1.5% in burn units and 32.5% in control units.

The spatial point pattern analysis, completed for each unit, provided a measure of baseline conditions at the time of the first series of burns. Nearest-neighbor analysis. Strong similarity exists between the 12 stands (Figure 3). These stands all exhibited significant clustering of stems at distances up to about 2 m from each stem; at larger distances the pattern became uniform, and be-

	Stem ha <sup>-1</sup>	% of total	Mean diameter (cm)	Total BA (m <sup>2</sup> )	Mean height (m)
P1ct 1: All stems	1491		14.8	33.12	--
Large live	63	4.2	64.4	22.09	32.4
Large dead	10	0.6	68.9	3.99	33.9
Suppressed	600	40.2	9.4	6.23	8.1
Small dead	51	3.4	5.0	0.15	4.8
Seedlings	767	51.4	--	--	--
P1ct 11: All stems	1462	--	12.7	34.28	--
Large live	34	2.3	79.6	18.38	36.6
Large dead	9	0.6	73.8	4.23	35.0
Suppressed	799	54.6	11.1	11.04	9.3
Small dead	197	13.5	5.1	0.62	5.0
Seedlings	423	28.9	--	--	--
P1ct 12: All stems	1719	--	9.7	27.46	--
Large live	52	3.0	54.3	13.67	28.9
Large dead	8	0.5	59.0	2.35	30.9
Suppressed	788	45.2	10.7	9.55	9.1
Small dead	821	47.8	4.7	1.90	3.9
Seedlings	60	3.5	--	--	--
P1ct 13: All stems	3403	--	6.7	30.98	--
Large live	49	1.4	59.9	15.50	30.8
Large dead	9	0.3	60.7	2.77	31.4
Suppressed	396	11.6	12.3	5.96	10.1
Small dead	2938	86.3	4.7	6.74	4.3
Seedlings	10	0.3	--	--	--
P1ct 21: All stems	509	--	16.1	28.3	--
Large live	62	12.2	64.0	22.07	32.2
Large dead	1	0.2	63.6	0.32	32.7
Suppressed	193	37.9	14.4	4.72	11.2
Small dead	253	49.7	6.5	1.16	6.1
P1ct 22: All stems	2674	--	8.8	32.22	--
Large live	36	1.3	67.3	13.86	33.2
Large dead	9	0.3	59.5	2.65	31.0
Suppressed	1677	62.7	8.4	15.08	7.4
Small dead	493	18.4	3.6	0.62	2.9
Seedlings	459	17.2	--	--	--
P1ct 23: All stems	2148	--	9.3	33.33	--
Large live	83	3.9	46.9	17.65	26.0
Large dead	16	3.1	62.3	5.05	32.1
Suppressed	650	30.3	10.7	7.64	9.1
Small dead	1395	64.9	4.8	2.98	3.8
Seedlings	4	0.2	--	--	--
P1ct 31: All stems	2505	--	10.1	42.50	--
Large live	94	3.7	45.0	19.22	25.1
Large dead	9	0.4	75.3	4.25	35.7
Suppressed	1062	42.3	12.1	15.23	10.4
Small dead	1338	53.4	5.4	3.78	5.2
Seedlings	2	0.1	--	--	--

Table 2. Stem density, relative density, mean stem diameter, basal area, and mean stem height by burn unit, Metolius Research Natural Area.

	Stem ha <sup>-1</sup>	% of total	Mean diameter (cm)	Total BA (m <sup>2</sup> )	Mean height (m)
Plot 43: All stems	2228	--	5.7	24.97	--
Large live	40	1.8	68.7	15.55	33.9
Large dead	7	0.3	84.6	4.04	38.4
Suppressed	598	26.8	5.2	4.24	4.9
Small dead	1382	62.0	3.0	0.68	2.6
Seedlings	201	9.0	--	--	--
Plot 52: All stems	2674	--	8.4	32.3	--
Large live	49	1.8	58.0	14.7	30.2
Large dead	9	0.3	55.1	2.3	29.7
Suppressed	1406	52.6	9.5	12.7	8.3
Small dead	1210	45.3	4.5	2.7	4.3
Seedlings	1	--	--	--	--
Plot 61: All stems	778	--	14.2	26.70	--
Large live	50	6.4	56.5	13.83	29.9
Large dead	10	1.3	60.7	3.09	31.4
Suppressed	422	54.2	13.5	8.20	10.8
Small dead	296	38.0	6.5	1.60	6.0
Plot 62: All stems	641	--	13.3	25.70	--
Large live	38	5.9	61.8	12.56	31.8
Large dead	21	3.3	71.0	8.64	34.6
Suppressed	135	21.1	13.1	2.47	10.5
Small dead	444	69.3	6.4	1.99	6.1
Seedlings	2	0.3	--	--	--

Table 2., continued. Stem density, relative density, mean stem diameter, basal area, and mean stem height by burn unit, Metolius Research Natural Area.

sis of all stems regardless of size was strongly influenced by the high density in most units. The empirical distribution for unit 43, based on 2228 points was greater than the theoretical distribution at distances less than about 2 m, suggesting significant clustering (Figure 2). The empirical distribution was less than the theoretical distribution and thus considered uniform for distances between 2 and 8 m. The empirical

distribution was within the 95% confidence envelope surrounding the theoretical distribution at distances greater than 8 m, suggesting a lack of departure from spatial randomness.

Strong similarity exists between the 12 stands (Figure 3). These stands all exhibited significant clustering of

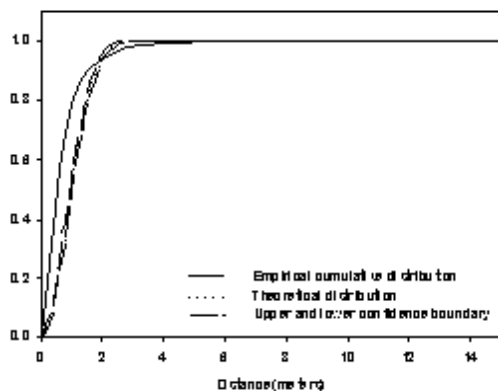


Figure 2. Results of nearest-neighbor analysis of all stems in unit 43, Metolius Research Natural Area.

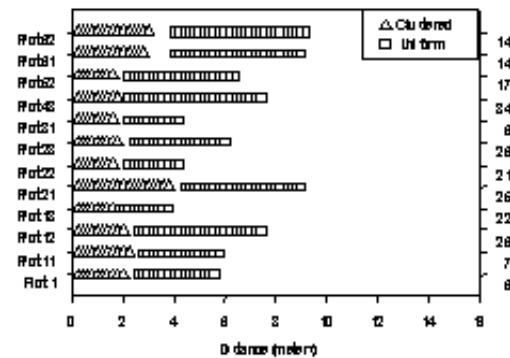
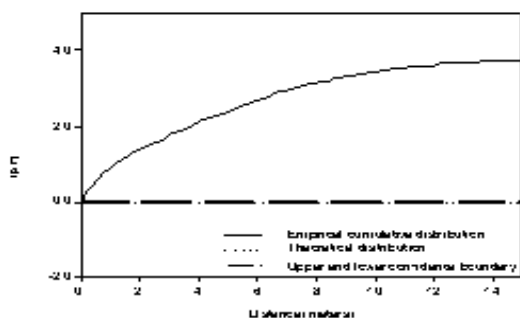


Figure 3. Deviations from a random point pattern, based on separate nearest-neighbor analyses of all stems in 12 burn units, Metolius Research Natural Area. Numbers along right axis are the number of stems in each unit.

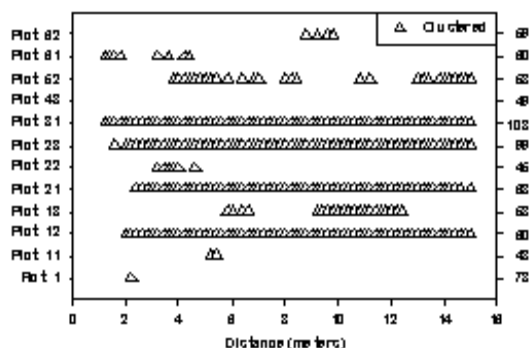
stems at distances up to about 2 m from each stem; at larger distances the pattern became uniform, and beyond 10 m was random.

Ripley's  $K(d)$  analysis, like the nearest-neighbor analysis, was strongly influenced by the density of stems in each unit. The empirical distribution of  $K(d)$  for unit 43, based on 2228 points, was greater than the theoretical distribution at all distances, suggesting significant clustering (Figure 4). Across all 12 1-ha plots,



**Figure 4. Results of Ripley's  $K(d)$  analysis for all stems in unit 43, Metolius Research Natural Area.**

significant clustering was found at all scales of distance from 0 to 15 meters (Figure 5). Studies of shade-tolerant conifers such as western hemlock (*Tsuga heterophylla* (Rafinascue) Sargent) and western redcedar (*Thuja plicata* Donn ex D. Don) in northern Idaho have shown that small, subdominant trees tend to be clustered, and large dominant trees tend to be more uniformly spaced (Moeur, M. 1997), leading to



**Figure 5. Deviations from a random point pattern, based on separate Ripley's  $K(d)$  analyses with large stems in 12 burn units, Metolius Research Natural Area. Numbers along right axis are the number of stems in each unit.**

the hypothesis that the clustering evident in these ponderosa pine stands is the result of large numbers of small intermediate and suppressed stems. Applica-

tion of Ripley's  $K(d)$  to just the dominant live and dead stems, representing on average the largest 5% of the total number of stems and most of the basal area, indicated that these large stems also were significantly clustered. Across all 12 plots, however, differences in this pattern were found (Figure 5). Some stands exhibit clustering of large trees, while others exhibit a random distribution. The hypothesized uniform distribution was found in only two stands, and at relatively small scales within the two stands. More commonly, the distribution of large ponderosa pine was either random or clustered. With additional burns, we have an opportunity to evaluate the effect of the actual burning pattern in relation to desired future condition of these stands, and consider the degree to which various frequencies of prescribed underburning mimic historic fires in severity and pattern.

## SUMMARY

We believe our efforts at the Metolius RNA represent a unique study of the long-term effects of reintroducing fire into fire-dependent ecosystems. Burns are scheduled at 5-, 10- and 20-year return intervals and occur within a RNA that has been protected from all manipulations for almost 70 years. This work requires a long-term commitment of time and resources because treatments will continue to occur for several decades. In addition to identifying the initial spatial point pattern and herbaceous response to burning, we will compare spring and fall burning effects, soil processes, and changes in the forest-floor light environment. We believe this study will increase our understanding of how natural disturbances and human-caused manipulations can affect forest health, and lead to new silvicultural options for protecting old-growth structural characteristics that are important for ecosystem integrity. We invite researchers with similar interests to consider joining us in collaborative work at Metolius RNA. Finally, our work has been possible only because of strong collaboration between staffs on the Sisters Ranger District and the Deschutes National Forest, and cooperation with neighboring private landowners.

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